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Description and Testing of a New Salmonid Egg Incubator

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ABSTRACT

Jordan, F. P. 1988. Description and testing of a new salmonid egg incubator. Can. Tech. Rep. Fish. Aquat. Sci. 1645: 15 p.

This report describes a new method of incubating salmonid eggs in natural or semi-natural environments. Its purpose is to increase substantially the rate of survival from potential egg deposition to fry emergence stage.

Survival of eggs of chinook and coho salmon averaged 91.5% and 85.9% respectively and survival was high whether eggs were planted "green" or at the "eyed" stage.

The incubation unit is simple, reusable, and easily planted into natural stream gravels.

RÉSUMÉ

Jordan, F. P. 1988. Description and testing of a new salmonid egg incubator. Can. Tech. Rep. Fish. Aquat. Sci. 1645: 15 p.

Le présent rapport décrit une nouvelle méthode d'incubation des oeufs de salmonidés dans des milieux naturels ou semi-naturels. Le but visé est d'accroitre de façon substantielle le taux de survie à partir de la ponte des oeufs jusqu'au stade l'émergence des alevins.

Le taux de survie des oeufs des saumons quinnat et coho s'est établi en moyenne à 91,5 et 85,9% respectivement et était élevé, que les oeufs soient mis en place "verts" ou "embryonnés".

L'unité d'incubation est simple, réutilisable et s'installe facilement dans le gravier des cours d'eau naturels.

INTRODUCTION

Salmonid eggs suffer substantial mortalities from the time of egg deposition to the fry emergence stage months later. Under normal or "wild" stream conditions, about 80% of all the eggs a female carries would perish. Some of the causes for this high loss are:

1) Not all eggs are fertilized when deposited.

2) Not all eggs are successfully buried.

3) Fungus from dead eggs will spread to healthy eggs.

4) Some eggs are eaten by predators at time of deposition.

5) Some eggs are covered with silt and suffocate.

6) Some eggs will dry up when the water level drops.

7) Some eggs will be dislocated during flood conditions.

The incubator described in this report is designed to provide a more protected incubatory environment for salmon eggs and, therefore, to increase substantially the survival rate from egg-to-fry stage.

METHOD AND MATERIALS

DIMENSIONS AND MATERIALS OF AN INCUBATION UNIT

Each incubation unit consisted of four sections, each containing 100 individual egg incubation chambers (Fig. 1, Fig. 2). Each section was made up of the following materials:

- Two pieces of 8 x 8 x 1/2 inch (205 x 205 x 13 mm) "plexiglass":

Into these pieces 100 circular egg chambers were drilled. The diameter of the egg chambers was 25/64 inch (9.9 mm). The chambers in both

pieces matched, giving each egg chamber a total length of one inch (25.4 mm).

- Two pieces of 8 x 8 x 1/8 inch (205 x 205 x 3 mm) "plexiglass":

These pieces were then glued to the outside of each 1/2 inch portion of a section. Holes were drilled to allow water to flow in and out of the chambers and to serve as exits for the fry after hatching. The escape can be made from either end of a chamber. The diameter for the escape holes was 7/32 (5.5 mm) for CHINOOK and 3/16 inch (4.8 mm) for COHO.

Spacers of 1/2 x 1/2 x 3 inch (13 x 13 x 75 mm) strips of "plexiglass" were glued to one side of a section, keeping sections apart to assist water circulation and provide an escape for emerging fry.

The sections were held together by four aluminum rods.

Fertilized eggs are placed in the individual chambers of each section by submerging one-half of a section into a supply of eggs. By removing this part, the eggs easily fall into place and fill the half chambers. The process takes only a few seconds and works like an egg counter used in hatcheries. With the chambers full, the second half of the section is fitted over the first securely locking each egg within its incubation chamber. Sections are separated by spacers and a number of sections are held together by rods to make up an incubation unit. These units are placed directly into the gravel at pre-selected locations of a streambed and covered with about three inches of medium-sized gravel (Fig. 3). By this method, a number of previous causes of low survival can be eliminated, namely;

1) All eggs are fertilized.

2) All eggs are deposited.

3) No disease from dead eggs will infect other eggs since eggs are not in contact.

4) No drying-up, silting, or dislocation of eggs occurs since sites have been carefully selected.

Most causes of high egg mortality have, thus, been eliminated. However, natural conditions will still apply after the fry emerge.

After the hatched alevin has absorbed most or all of its yolk sac, and become a "fry" it will be able to leave its chamber by passing through the escape hole at either end of the chamber.

TESTING OF THE UNITS

Four different situations were chosen:

1) To determine the survival rate from egg-to-fry using "green" eggs:
The eggs are water-hardened for one hour after fertilization. This would apply when salmonids with ripe eggs are available in a wild stream and no facilities are nearby to bring the eggs to the "eyed" stage. Unit No. 1, containing 400 CHINOOK eggs, was planted in a wooden trough measuring 10 in. x 10 in. x 6 ft. (25.4 cm x 25.4 cm x 1.8 m). The unit was covered with medium-sized gravel. The water inflow was measured to be about 8 litres/min.

2) To determine the survival rate using "eyed" eggs:
This would apply when using excess hatchery eggs. Unit No. 2, holding another 400 CHINOOK eggs, was placed into the same wooden trough as Unit No. 1 about 1.5 ft. (46 cm) further downstream.

3) To determine the survival rate of "eyed" eggs without the use of gravel:
This situation could apply if eggs were incubated in boxes, away from streams but not in hatcheries. Unit No. 3, containing 400 CHINOOK eggs, was placed on the bottom of a circular fiberglass tank measuring 3 ft. (0.91 m) in diameter and containing approximately 300 litres of water to a depth of 18 inches. The inflow of water was measured to be about 8 litres/min.

4) To determine the rate of survival of "eyed" eggs in a natural environment:
Unit No. 4, containing 400 CHINOOK eggs, was placed into the gravel of NANOOSE CREEK, located approximately ten miles north of Nanaimo, B.C.

The above procedures were repeated with COHO eggs using units No. 5, 6, 7, and 8 except that the "green" eggs of coho were incubated in the circular tank without gravel rather than the wooden trough with gravel.

To test the survival of "green" and "eyed" for CHINOOK and COHO in all three different incubation environments, a total of 12 units would have been necessary. Unfortunately, only eight were available so that only two tests of "green" eggs were conducted.

A control group of 400 eggs of each species tested was kept in a hatchery tray. Each tray had been treated with malachite green up to the "eyed" stage.

RESULTS AND DISCUSSION

Average survival rates in the incubators ranged from 65.5% to 98%, much better than the expected natural survival rate of 20% (Table 1). The low survival of 65.5% occurred in Unit No. 8 containing coho eggs that was placed in Nanoose Creek. On removal of this unit from the gravel I observed that the dead eggs remaining in the egg chambers were surrounded by very fine sand. It is likely the eggs had suffocated due to this accumulation of fine sand.

At the start of these tests I was concerned that eggshells might block the chamber outflows shortly after hatching and so reduce the flow of oxygenated water through the chambers. Fortunately, this did not happen. There was no evidence of eggshells in the empty chambers.

A second concern was that the upstream sections of a unit would use up the available oxygen in the water so that the downstream sections would not get sufficient oxygen for survival. No evidence was found in decreased survival from upstream to downstream sections (Table 1).

A third concern was that fungus on dead eggs would spread without egg-to-egg contact. In that case, the rate of the fungus infection should have increased from upstream to downstream sections. This concern could be examined in the wooden trough with gravel in which the upstream to downstream ordering of incubation units was: "green" chinook eggs; "eyed" chinook eggs; "eyed" coho eggs. Any transport of infection between sections or units should have been apparent. In fact, the most infected unit proved to be the most upstream unit with "green" eggs. The two downstream units containing "eyed" eggs suffered a lesser fungus infection and experienced survival from 96% to 100% (Table 1).

An unexpected result was that the hatched alevins did not remain in the chambers until total absorption of their yolk sacs. In the case of the chinook, slightly smaller escape holes could have been used because the alevins were able to squeeze out of the chambers soon after hatching. However, no fry emerged from the gravel until the "button-up" stage much later. It may even be desirable for the alevins to escape and find their own spot in the gravel until development is complete and the fry is ready to emerge. Coho were more advanced in development; almost buttoned-up, when they left the incubation units.

Since there is a considerable range of egg sizes and resulting fry sizes, it is necessary to make the exit holes large enough to permit all fry to leave the chambers and not to imprison the larger ones. It is also important to provide large enough incubation chambers to accommodate any size

salmonid egg and to ensure proper waterflow around the egg during incubation. The dimensions of the chambers and escape holes will have to be tailored somewhat to specific sizes or species of salmonids. Therefore it will be necessary to make up more than one mold to accommodate these differences.

Before the units are produced commercially, some changes should be made in the design to make the use of incubation units more efficient:

1) The incubators should be constructed of injection-molded, non-toxic smooth plastic for mass production.

2) Instead of four pieces of plastic as used in the prototype, only two pieces would make up a section.

3) The upstream half of each section should be thinner, making that portion of the incubation chambers shallow enough to hold only one egg per chamber when loading. In the prototype used, the section halves were of equal thickness and sometimes two eggs landed in one hole. In that case extra handling was necessary and extra time was spent. The downstream half of the section should, of course, be made thicker so as not to sacrifice final chamber size.

4) One edge of the "loading", or thinner, half of a section should be bevelled and rounded. This would prevent injuring any eggs when dipping this half of a section into a supply of eggs as no sharp edge would come in contact with them.

5) The water intake and outlet holes should be located at the bottom part of the chambers. This way no egg could block the flow of water, which might happen if the holes were located in the center and eggs would roll against this opening. Another advantage to having the inlet and outlet holes at the bottom would be that the alevin in the chamber could sweep out any silt or fine sand with the movements of its tail.

6) More egg chambers should be drilled in each section. Only 100 were used in the prototype but, by placing the chambers closer together, it should be possible to accommodate about 300 chambers per section with little increase to the size of the units. The incubation units should not become too large since that would necessitate digging deeper into stream beds and often the gravel depth is shallow.

7) Alignment pins and holes, as part of the manufactured section parts, would ensure quick and exact fit of the chambers.

8) Only two rods, instead of four will be necessary to hold the sections together to form an incubation unit.

9) Spacers between sections would be part of a section portion and will enable alevin or fry to exit from the upstream or downstream side of a section.

10) When using incubation units for different species, it will be necessary to make up units of slightly different size egg chamber holes and escape holes to take into consideration the difference in egg and fish sizes between species of salmonids.

11) Colour-coding the plastic should be useful for quick identification of the proper unit size to be used.

APPLICATIONS

The incubation units would provide some valuable advantages:

1) They are fully portable and could be used to establish fish runs in barren streams or to enhance streams which are underutilized without having to build hatching facilities.

2) After planting, there is no maintenance. When all fry have left the gravel, the units can be removed, cleaned and stored for re-use.

3) Mortalities can be determined by subtracting the dead eggs which cannot pass through the narrower fish exit holes from the total number of eggs planted.

4) Eggs could be planted "green" right after fertilization if mature fish are available or "eyed" using excess fish from hatcheries.

5) Besides using the incubation units in the gravel of streams, they could be used in boxes with a layer of gravel at the bottom to provide the fry with shelter before finally emerging. A supply of clean water is the only requirement. This should be of interest to trout farmers or people who live with access to a stream and like to get involved in salmon enhancement.

6) An incubator planting should be a smooth operation. Streams and plant sites can be selected well ahead of time. Hatchery personnel would know at the time of the egg take how many eggs could be made available. The actual planting of the incubator units should take only a short time since the sites can be readied in advance.

Even though natural conditions will apply after hatching, the initial survival rate from egg to fry will have been increased from about 20% to 80-90%.

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My thanks to Mr. Don Lawseth and crew of the D.F.O. Robertson Creek hatchery and Mr. Grant Ladouceur and crew of the D.F.O. Big Qualicum hatchery for making eggs available for the experiment.

And thanks to the personnel of the P.B.S. Rosewall Creek facility for their help to set up the experiments.

Table 1. Egg to fry survival in an experimental egg incubator under different test conditions. Sections 1-4 are numbered upstream to downstream. See text for details of placement conditions.

			CHINOOK									
			**"GREEN EGGS"						***"EYED EGGS"			
PLACEMENT	UNIT NO.	SECTION NO.	TOTAL NO.	NO. LIVE	NO. DEAD	PERCENT SURVIVAL	UNIT NO.	SECTION NO.	TOTAL NO.	NO. LIVE	NO. DEAD	PERCENT SURVIVAL
CIRCULAR TANK	-	-	-	-	-	-	1	1	100	99	1	99.0
							1	2	100	95	5	95.0
							1	3	100	96	4	96.0
							1	4	100	96	4	96.0
GRAVEL TROUGH	2	1	100	78	22	78.0	3	1	100	98	2	98.0
	2	2	100	76	24	76.0	3	2	100	97	3	97.0
	2	3	100	82	18	82.0	3	3	100	97	3	97.0
	2	4	100	90	10	90.0	3	4	100	100	0	100.0
WILD STREAM	-	-	-	-	-	-	4	1	100	84	16	84.0
							4	2	100	94	6	94.0
							4	3	100	89	11	89.0
							4	4	100	93	7	93.0
CONTROL GROUP IN HATCHERY TRAY							-	-	400	399	1	99.8

Table 1 (cont'd)

COHO

PLACEMENT	*"GREEN EGGS" UNIT NO.	SECTION NO.	TOTAL NO.	NO. LIVE	NO. DEAD	PERCENT SURVIVAL	***"EYED EGGS" UNIT NO.	SECTION NO.	TOTAL NO.	NO. LIVE	NO. DEAD	PERCENT SURVIVAL
CIRCULAR TANK	5	1	100	89	11	89.0	6	1	100	94	6	94.0
	5	2	100	88	12	88.0	6	2	100	96	4	96.0
	5	3	100	91	9	91.0	6	3	100	89	11	89.0
	5	4	100	84	16	84.0	6	4	100	95	5	95.0
GRAVEL TROUGH							7	1	100	97	3	97.0
							7	2	100	96	4	96.0
							7	3	100	96	4	96.0
							7	4	100	97	3	97.0
WILD STREAM	-	-	-	-	-	-	8	1	100	37	63	37.0
							8	2	100	68	32	68.0
							8	3	100	75	25	75.0
							8	4	100	82	18	82.0
CONTROL GROUP IN HATCHERY TRAY							-	-	400	395	5	98.8

*"GREEN EGGS" - One hour after fertilization.
**"EYED EGGS" - From Hatchery tray.

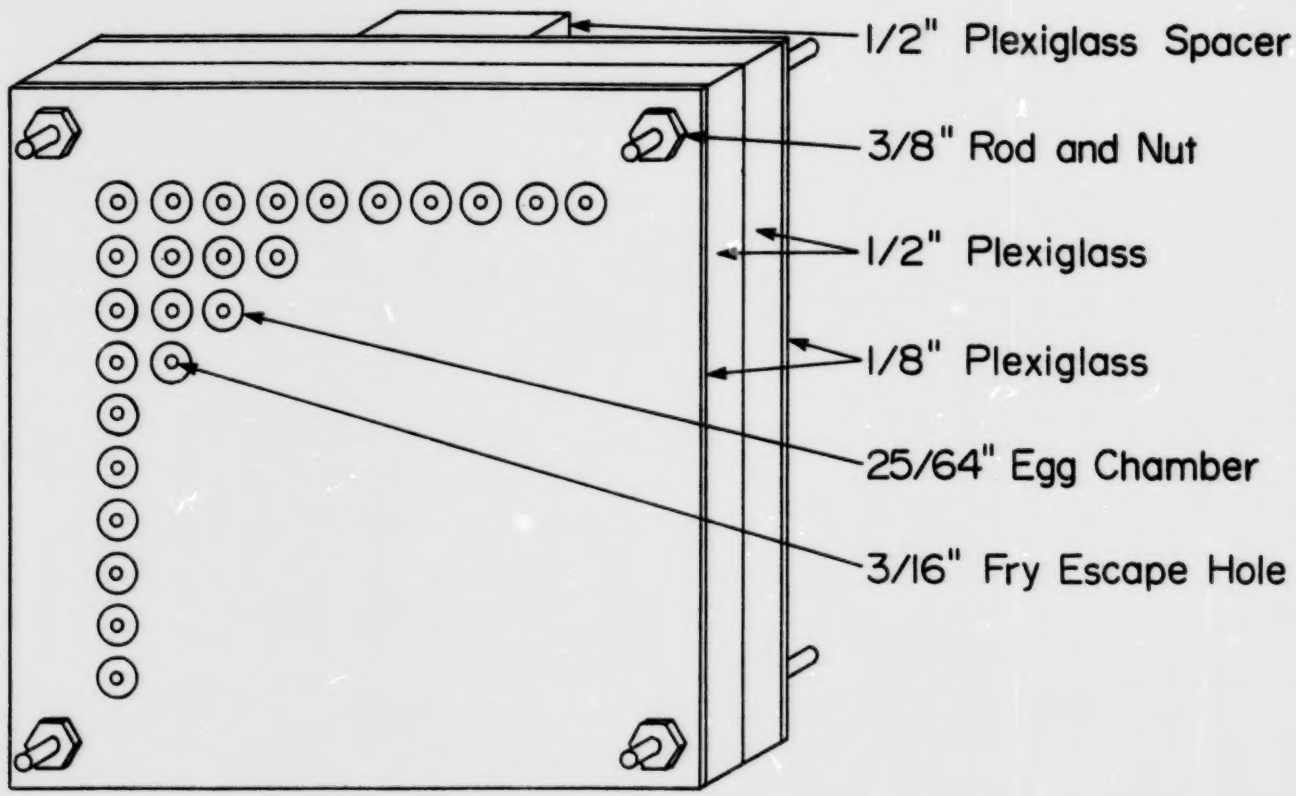

Fig. 1. Salmonid egg incubator - Front view.

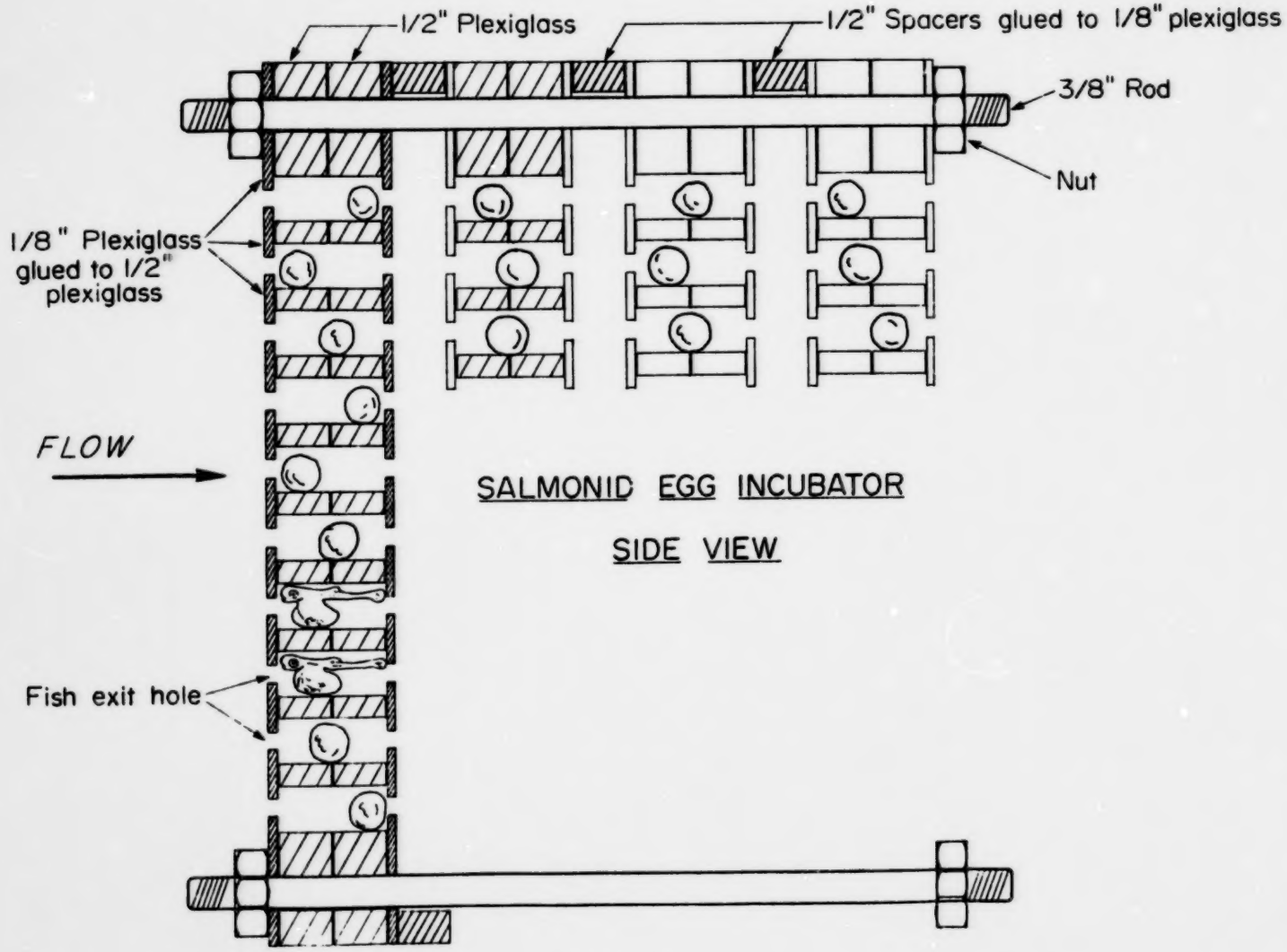

Fig. 2. Salmonid egg incubator - Side view.

SALMONID EGG INCUBATOR

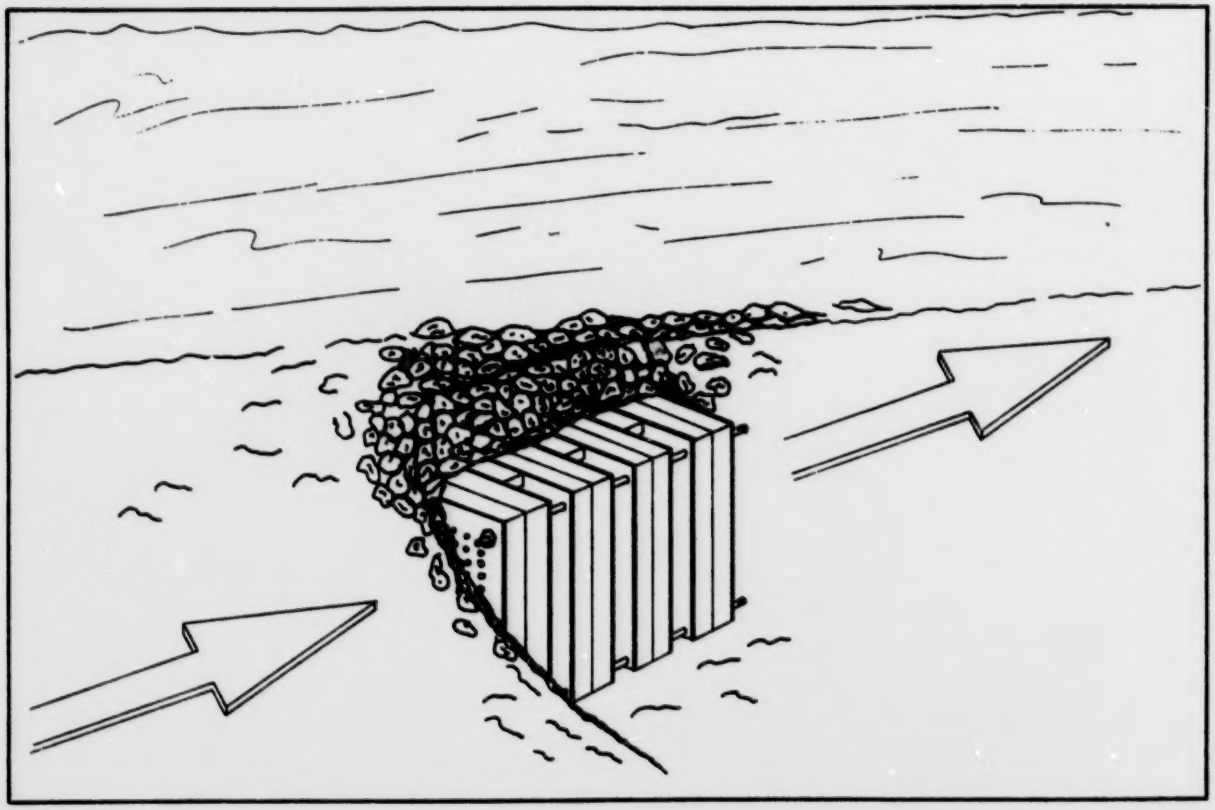

Fig. 3. Incubator buried in gravel of streambed.